

SULFATES IN IANI CHAOS, MARS. M. S. Gilmore¹, J. P. Greenwood¹, J. L. Bishop², ¹Department of Earth and Environmental Sciences, Wesleyan University, 265 Church St., Middletown, CT 06459, mgilmore@wesleyan.edu. ²Carl Sagan Center, SETI Institute, Mountain View, CA.

Introduction: Significant sulfate deposits have been found on Mars using orbital and rover data, and include the interior layered deposits (ILD) of the Valles Marineris, Meridiani Planum, and chaos regions east of Valles Marineris: Aram, Iani and Aureum [e.g., [1-7]. Here we focus on the layered deposits within Iani Chaos, part of the Margaritifer – Ares Valles outflow system in the southern hemisphere of Mars. These deposits have high thermal inertia and high albedo relative to their surroundings [4,5]. Previous work using Mars Express Observatoire pour la Minéralogie, l'Eau, les Glaces, et l'Activité (OMEGA) hyperspectral data identified polyhydrated sulfates in central and southern Iani Chaos, perhaps consistent with gypsum or bassanite [1, 4]. These sulfates coincide spatially with crystalline hematite deposits identified in Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) data [4,5]. Here we examine these deposits using high-resolution image and spectral data provided by instruments on the Mars Reconnaissance Orbiter (MRO).

Geomorphology: MRO Context Camera (CTX) and HiRISE data were radiometrically and geometrically corrected in Integrated Software for Imagers and Spectrometers (ISIS) and merged with Mars Odyssey Thermal Emission Imaging System (THEMIS) and MGS Mars Orbiter Laser Altimeter (MOLA) basemaps in ArcGIS. CTX scenes were also overlaid onto Mars Express High Resolution Stereo Camera (HRSC) DEMs in ENVI 4.5. Three primary deposits of these materials are present in Iani covering a total area of ~6000 km² (~Great Salt Lake). The deposits lie in topographic lows within Iani and form mounds of material 100s of meters high (range ~ 0 – 1 km).

The deposits typically have a fractured and polygonal texture at the 1 - 10 m scale and preserve few craters. They are found to form cliffs that are actively eroding into blocks and rockfalls. In north Iani, differential weathering along pervasive N-S trending joints is evident. The deposits are commonly layered at the several meter scale.

Bright, layered deposits are recognized within the mounds that comprise the chaos terrain itself. The layered deposits within the mounds are conformable to exposed layered deposits suggesting that the deposits are exposed by differential weathering (likely along fractures) between the chaos mounds. In central Iani, a second generation of layered deposits embays the eroded chaos mounds (also noted by [4,5]). These deposits onlap onto the mounds and can be seen to

extend 100s of meters up the mound slopes (Fig. 1). Eroded mesas of this material 100s m - ~1 km high can also be found outside the primary deposit. These landforms suggest that the secondary deposit was once thicker and has been eroded away with time.

CRISM Analysis: CRISM images were processed using the CRISM Analysis Tool (CAT) v. 6.5, which applies photometric, geometric and atmospheric corrections. Here we report on analyses of images (FRT0000) 8158 and 7e16, which lie in the central bright deposit of Iani. Spectral data were examined over the 1.0 - 2.6 μ m range and classified using CAT summary products [8]. Three major spectral units are described (Fig. 2): Unit A includes major absorptions at 1.96, 2.39 and 2.54 μ m and unit B contains absorptions at 1.97, 2.08, 2.14, 2.4, and 2.54 μ m, unit B has lower values of BD1900R, SINDEX and higher values of D2300 than the other two units. We interpret unit A to be a polyhydrated sulfate; several Mg and Fe sulfates are consistent with this spectrum, including but not limited to, hexahydrite (MgSO₄•6H₂O), rozenite (FeSO₄•4H₂O) and melanterite (FeSO₄•7H₂O). Unit B is interpreted to be monohydrated sulfate, most likely kieserite (MgSO₄•H₂O).

Stratigraphy and Geologic History: In central Iani, the monohydrated sulfate deposits are found within and between the chaos mounds. Monohydrated sulfate deposits consistently underlie polyhydrated sulfate deposits where the units are observed in contact (Fig. 3). In many cases, it appears that the monohydrated sulfates are being exposed as the polyhydrated unit is eroded away above it. We propose the following stratigraphic sequence in central Iani: 1) the regional deposition of a 100s meters thick deposit of sulfate that is monohydrated at present. This sulfate may be primary, or may have formed by the metamorphism of more hydrated sulfates. 2) Erosion of these deposits to form mounds. This could be accomplished along fractures associated with chaos formation or by fluvial processes. 3) Local deposition of polyhydrated sulfates. 4) Erosion of this deposit. Monohydrated and polyhydrated sulfates have been identified in the ILDs of Valles Marineris [9], and show a similar stratigraphic relationship in Candor Chasma [7].

Geochemical Model: A mean deposit thickness of 500 m yields 3000 km³ of sulfates for the whole of Iani. We derive an initial estimate the volume of water necessary to precipitate this amount of sulfate in Iani Chaos using Geochemists' Workbench. The modeling

predicts that this deposit would require the evaporation $3.5 \times 10^5 \text{ km}^3$ of terrestrial seawater. Since magnesium sulfates (mainly epsomite and kieserite) comprise ~80% of sulfates precipitated in the model, if all sulfates in Iani are Mg-rich, they would require the

evaporation of $4.2 \times 10^5 \text{ km}^3$, or approximately the volume of the Black Sea. Our stratigraphy suggests that this water was delivered in at least two episodes of flooding, consistent with hydrologic modeling of Iani Chaos [10] and mapping of Ares Valles [e.g., 11].

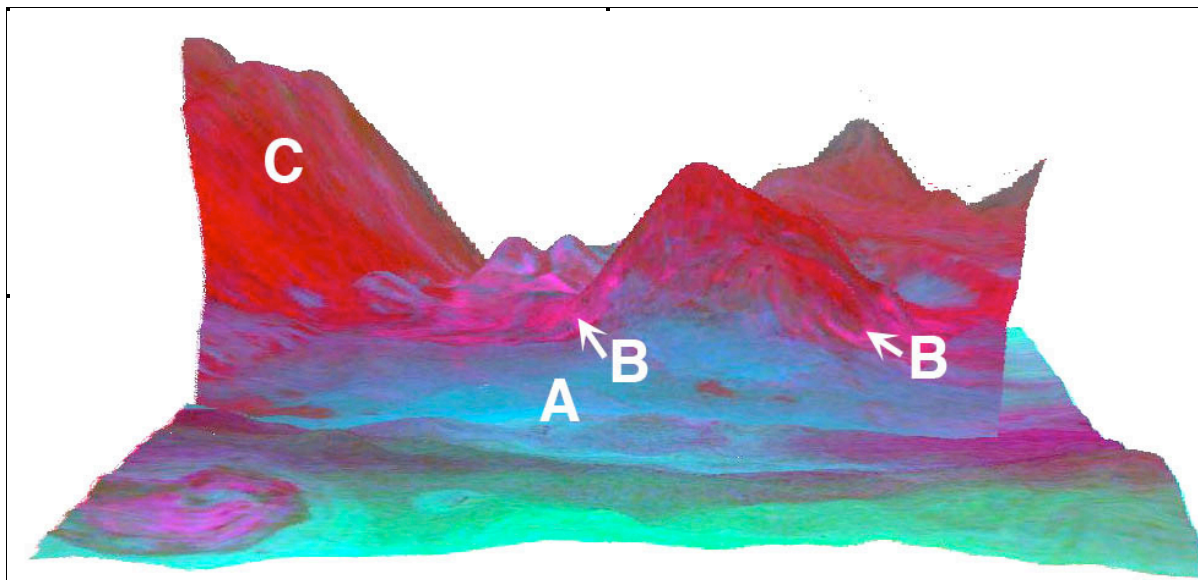


Fig. 1. CRISM mosaic of FRT 7e16 (foreground) and 8158. RGB = BD2100, BD1900R, SINDEX (CAT summary data products) overlaid on HRSC data. Vertical exaggeration = 5X, north is to the left. Blues and greens are polyhydrated sulfates, purples are monohydrated sulfates, reds are weathered surfaces and aeolian deposits.

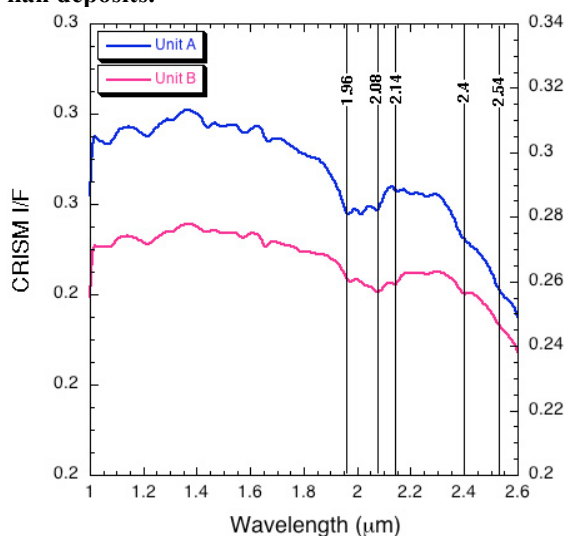


Fig. 2. Spectra of units identified in Fig. 1. Major absorptions are identified.

References: [1] Gendrin et al. (2005) *Science* 307, 1587. [2] McClellan et al. (2005) *EPSL* 240, 95. [3] Glotch and Christensen (2005) *JGR* 110, E09006. [4] Noe Dobrea et al. (2008) *Icarus* 193, 516. [5] Glotch and Rogers (2007) *JGR* 112, E06001. [6] Mangold et al. (2008) *Icarus* 194, 519. [7] Murchie et al. (2009) *JGR* 114, E00D05.

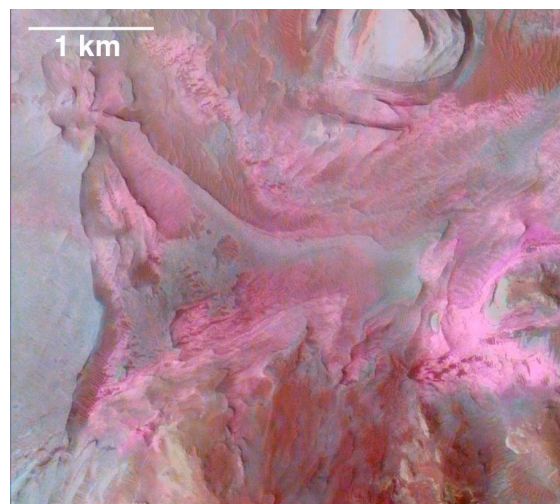


Fig. 3. CRISM image FRT8158 overlain onto CTX image P07_003907_1780_X1_02S017W. Band designations are as in Fig. 3. Monohydrated sulfates (pink) are overlain by polyhydrated sulfates (blue). [8] Pelkey et al. (2007) *JGR* 112, E08S14. [9] Roach et al., (2009) *JDR* 114, E00D02; Bishop et al., *JGR* 114, E00D09. [10] Andrews-Hanna and Phillips (2007) *JGR* 112, E08001. [11] Warner et al. (2009) *EPSL* 288, 58. Thanks to the Mustard lab at Brown for help with CRISM processing.